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ABSTRACT

The DIATEST responder system is a control system for fully programed running of diagnostic tests of multiple-choice type. The system makes use of the control unit earlier developed at the Institute of Technology for programed four-screen slide projection and the electronic response analyser (ESAU). Presentation of a question is done audiovisually, both from channel 1 on a stereo tape recorder and from a question projector. The choice of answer is displayed with four other projectors. Pulses from channel 2 of the tape recorder are used for control of slide changing and for information of correct answer and scanning to ESAU. A special programing unit has been developed for facilitating the recording of programed tests. The DIATEST system has been used with good results in the regular teaching of applied electronics during the year 1969/70. Detailed circuit diagrams of the control units are presented in an appendix. (Author/MF)

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REPORT PE-7

DIATEST, A SYSTEM FOR PROGRAMME CONTROL OF MULTIPLE CHOICE TESTS

Department of Education, KTH

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May, 1970

Christer Eriksson

This project has been financially supported by the Swedish Board of Technical Development.

Summary

The report describes the DIATEST responder system, which is a control system for fully programmed running of diagnostic tests of multiple choice type. Both the presentation of questions and collection of answers take place automatically.

The system makes use of the control unit earlier developed at the Institute of Technology for programmed four-screen slide projection and the ESAU electronic response analyser.

Presentation of a question is done audiovisually, both from channel 1 on a stereo tape recorder and from a question projector. The choice of answer is displayed with four other projectors.

Pulses from channel 2 of the tape recorder are used for control of slide changing and for information of correct answer and scanning to ESAU.

A special programming unit has been developed for facilitating the recording of programmed tests.

The DIATEST system has been used with good results in the regular teaching of applied electronics during the year 1969/70.

Detailed circuit diagrams of the control units are presented in an appendix.

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1. BACKGROUND AND TERMINOLOGY

For the teaching of applied electronics we often use still films.

By still film we mean the automatic showing of slides controlled and commented on from the tape recorder.

In order to be able successively to build up a more complicated figure, we have produced still films with simultaneous projection of up to four slides. We call this "four-screen slide projection" (fig. 1); for control of the projectors a pulse receiver (PR) is required, which controls the projectors according to the pulse code from the tape recorder.

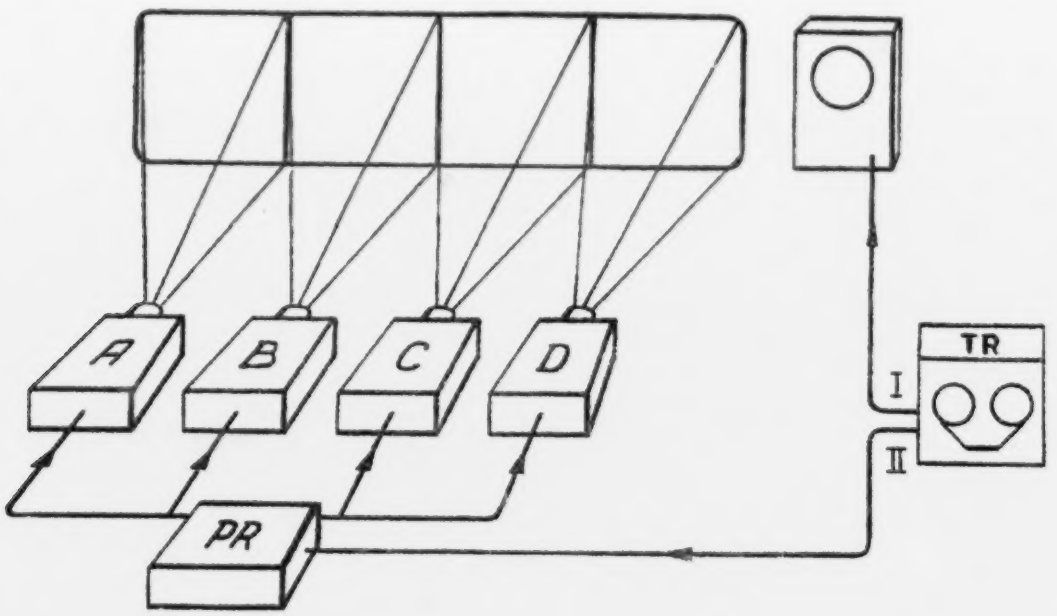

Fig. 1 System for programme control of four-screen slide projection from tape recorder
PR = pulse receiver
A - D = projectors
TR = 2-channel tape recorder

ESAU is the Swedish abbreviation for "electronic response analyser". ESAU consists of a number of student terminals, each with four buttons. On command ESAU scans the student terminals and allots one point to every student who has pressed the correct answer button, to which ESAU has been set during the scanning (fig. 2).

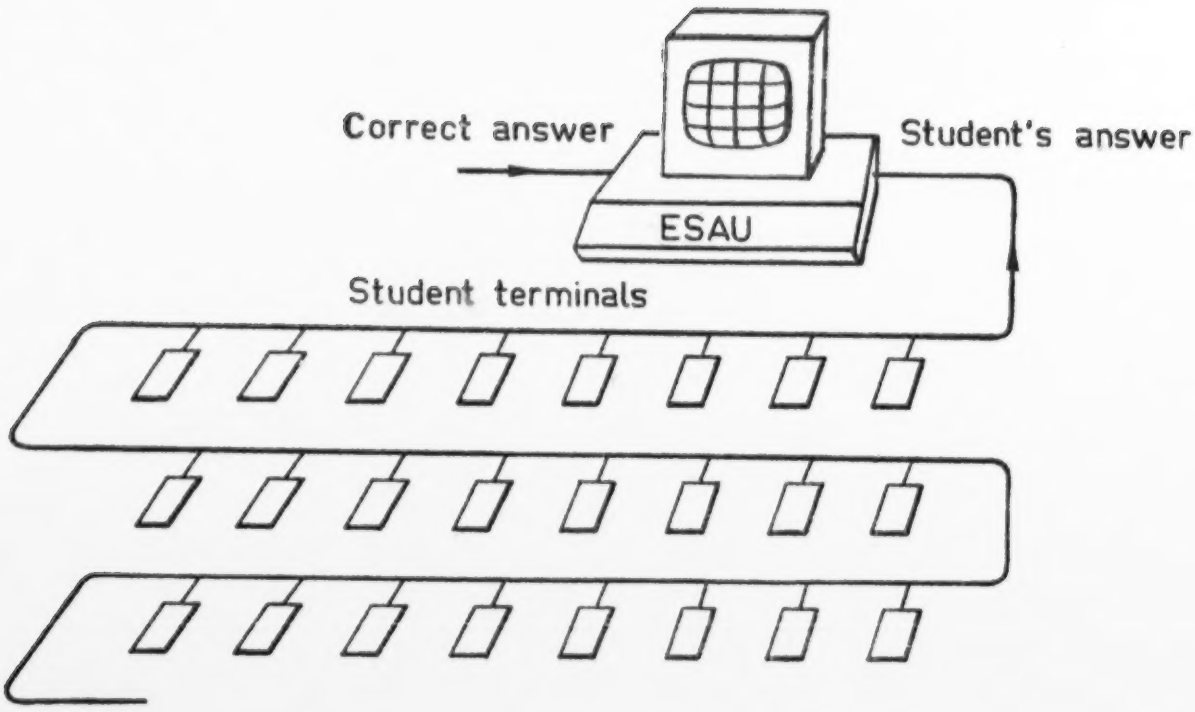

Fig. 2 ESAU, electronic responder for multiple choice tests

ESAU has two registers, a student score register which contains the number of correct answers from each student, and a question score register which contains the number of correct answers to every question (i.e. for every scan). A TV monitor is used as display for the registers, and the registration takes place through photography of the TV picture.

2. DIATEST AND ITS SPECIFICATION

DIATEST is a responder system based on five-screen projection for presentation of four-choice questions, ESAU for registration of student score and question score, and a special control equipment for projectors and correct answer presentation. This report deals with the function and construction of the control equipment.

Our specification of DIATEST was based on our earlier experience of multiple choice tests. This may be summarized as follows:

1. The choice of four answers is a suitable compromise in view of the difficulty of designing appropriate distractors and the risk of a high score as a result of pure guesswork.

2. The alternative answer must be shown on separate screens. This gives a clearer presentation and does not lock the relative order of the various alternatives.

3. The question should be displayed on a separate screen and remain displayed during the entire time for consideration.

4. After scanning with ESAU the correct answer must remain displayed for a while for reinforcement of learning. Fig. 3 shows a question- and-answer cycle on the basis of the points above.

5. Change of slide and transmission of the correct answer to ESAU must be automatically controlled from the tape recorder.

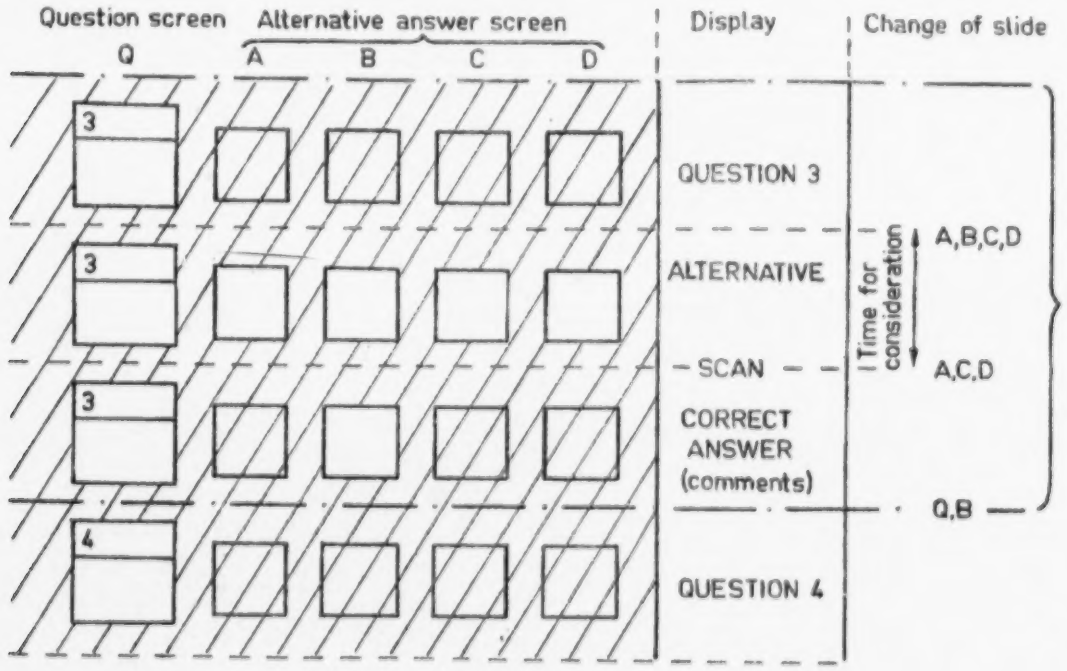

Fig. 3 Cycle for display of question, alternative answers and correct answer. In this example the correct answer is B.

3. PROGRAMME CONTROL FOR PLAYBACK

It will be seen from fig. 3 that every operation in the cycle is preceded by a change of slide in one of projectors A, B, C or D. This means that we can use the earlier described four-screen system, in which four projectors can be controlled entirely independently of one another.

Apart from the control of the alternative projectors A - D, certain combinations of signals must control the question projector Q and the transmission of the correct answers to ESAU. The pulse receiver PR must therefore be supplemented by a correct answer and question decoder, the CAQ decoder. The principle of DIATEST is shown in fig. 4.

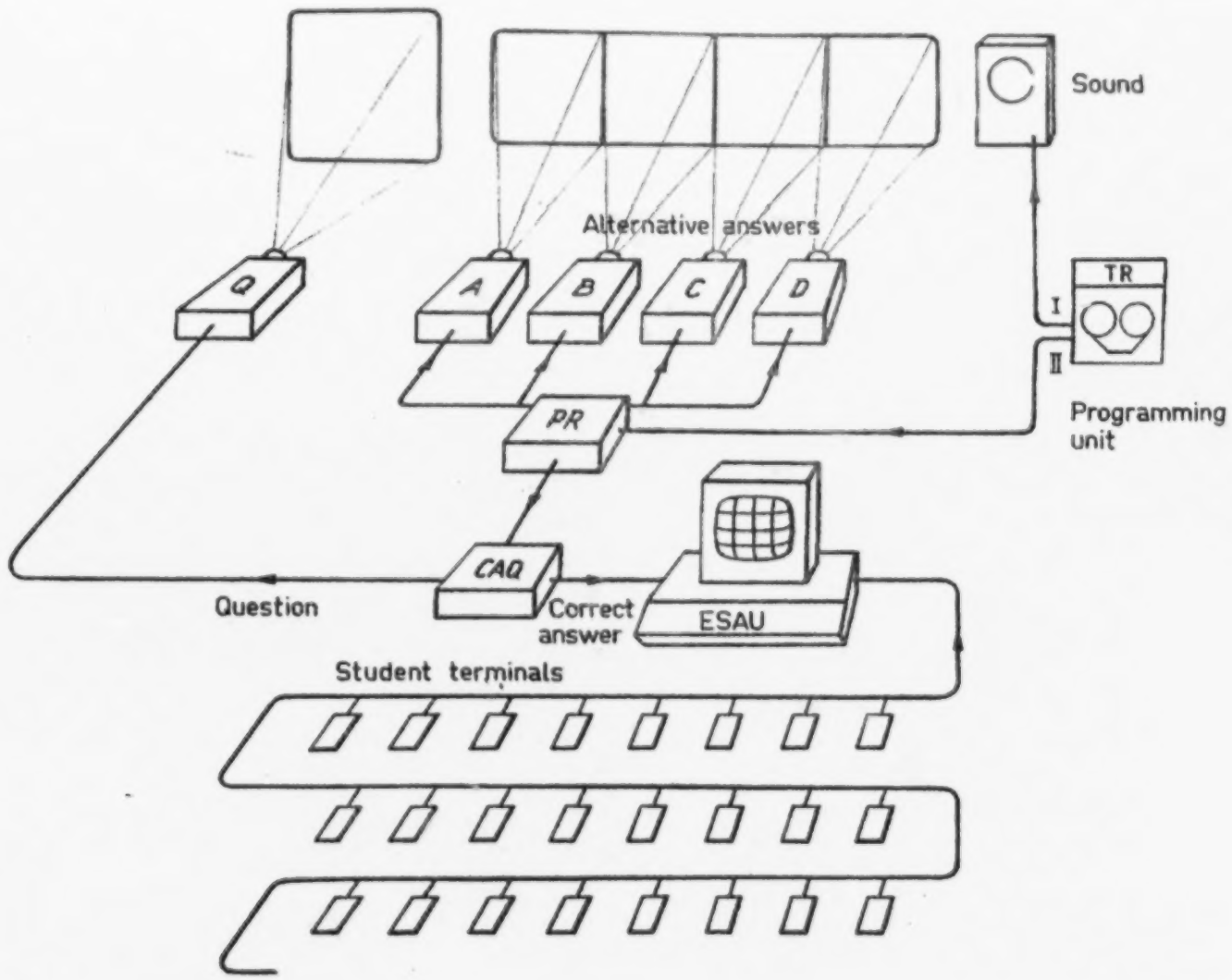

Fig. 4 The programme-controlled responder system DIATEST

4. PROGRAMMING UNIT FOR RECORDING

The recording of a test requires a question text and possibly also sound effects such as "ding-dong" for indication of time for consideration etc.

The programming of a test also requires the recording of trigger pulses which can be recorded on another channel on the tape. This programming would be very time-consuming and would also require an expert if it were done directly with the pulse generator (PG) for the four-screen system.

We therefore developed a programming unit which greatly simplified the entire recording procedure. On the basis of the time diagram for a question-and-answer cycle (fig. 5) we specified the controls and functions which the programming unit should have (see Appendix A). The chief functions are: start, time for consideration, and correct answer. During the development period, furthermore, we have found it necessary to be able to prolong the time during which the correct answer is displayed in order to allow comments to be made upon it. For this reason the "comment" button was introduced.

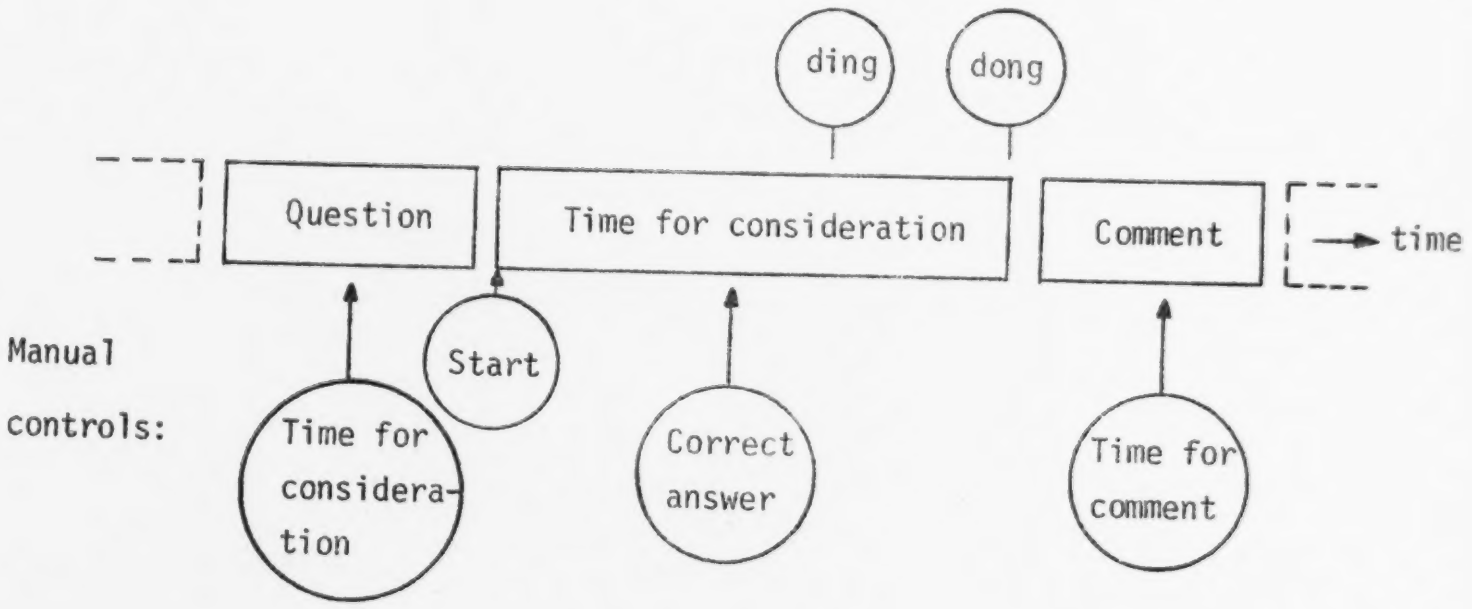

Fig. 5 Time diagram for a whole question-and-answer cycle with manual controls for programming. Each block represents one slide combination.

In order to be able to programme earlier recorded test tapes, a direct-acting scanning control which terminates the time for consideration was also required.

A prototype of the programming unit is shown in fig. 6.

Fig. 7 shows the principle of the entire recording equipment.

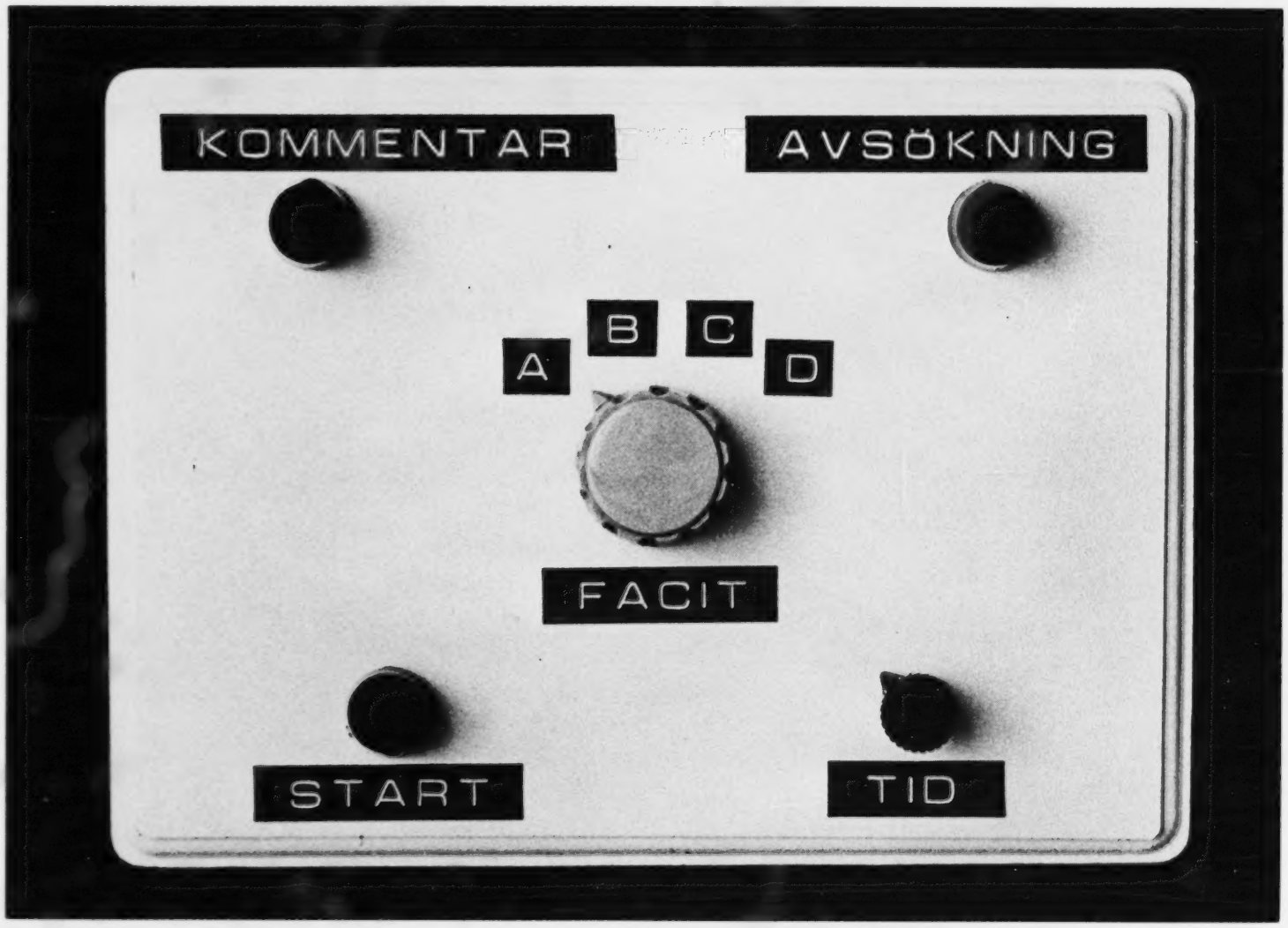

Fig. 6 The programming unit with its controls

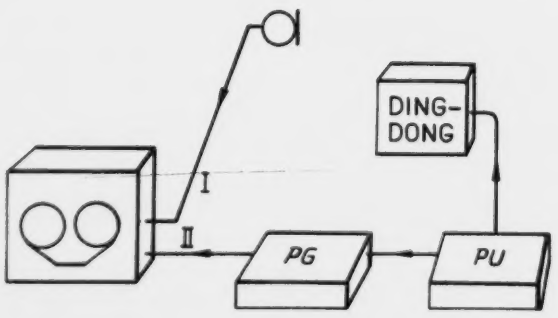

Fig. 7 Principle of recording equipment for programme-controlled tests

5. EXPERIENCE FROM USE OF DIATEST

Several diagnostic tests have been programmed and run during the autumn term of 1969 for some 150 students of the Institute of Technology. Apart from certain noise problems at the outset the system has proved very reliable and, above all, has facilitated the actual running of the test. See fig. 8.

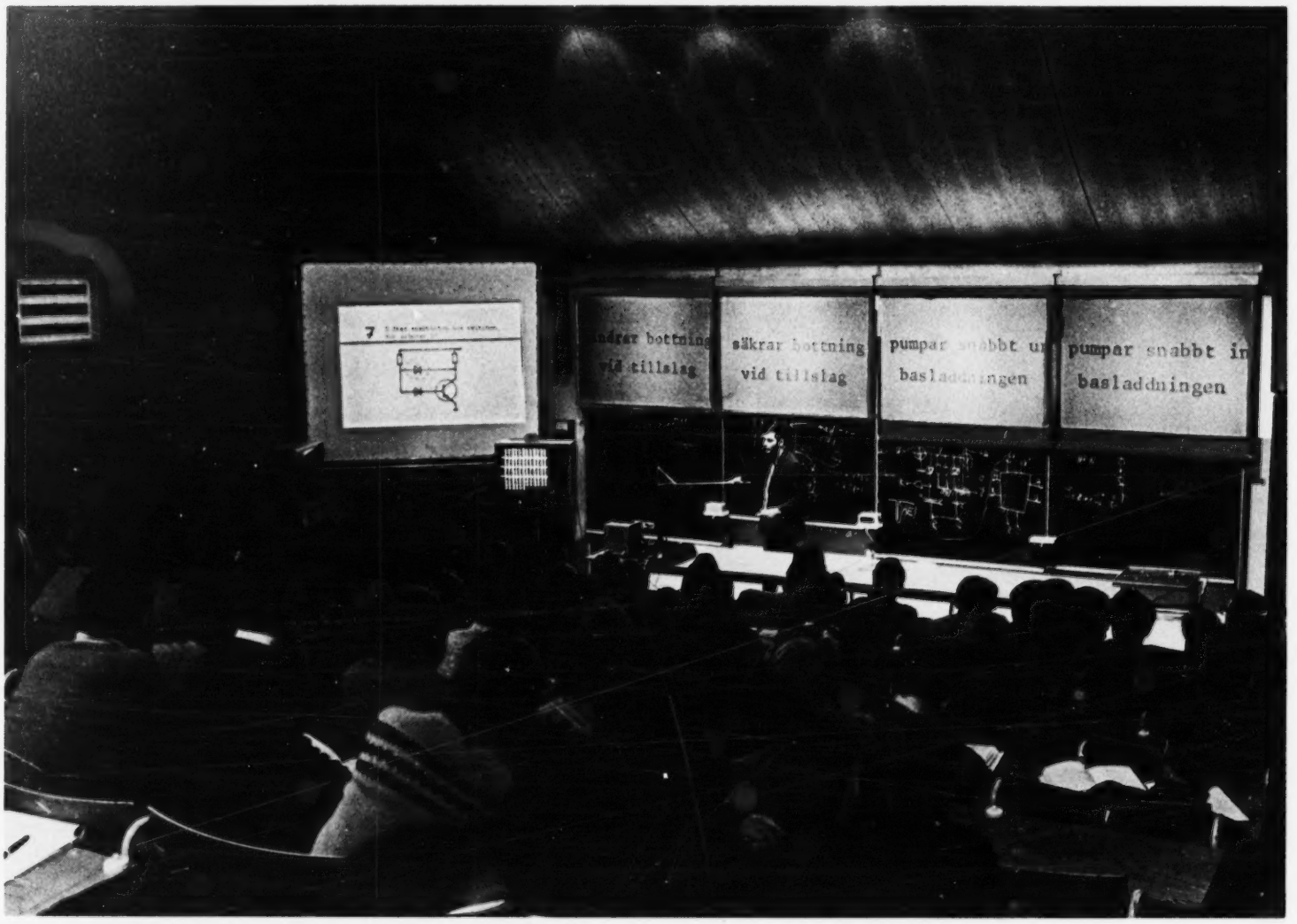

Fig. 8 The DIATEST system used in a regular course in electronics at the Royal Institute of Technology in Stockholm

The diagnostic tests have successively changed from being solely a check of knowledge to having a direct activating and learning function, and the questions often lead to a lively discussion. It is then often important to be able to consider and discuss the distractors as well. For transmission of the correct answers to ESAU use is made precisely of the fact that the distractors disappear from the screen. In order to be able to transmit the correct answer without removing the distractors, a larger number of channels is required than the present four.

Another way of circumventing the difficulty in transmission of the correct answer is to present question and alternative answers on the same screen. It is tests of this type that have been run during the autumn term of 1969.

Continued trials have not been possible during the spring term of 1970 as the ESAU owned by the Committee for the Use of Television and Radio in Teaching has been taken from the Institute of Technology for other experiments.

An evaluation of the system in the regular teaching of Transistor Pulse Circuits at the Institute of Technology can, therefore, not be made at the moment.

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APPENDIX A. SYNTHESIS OF LOGIC CIRCUITRY

To investigate how the earlier four-screen system should be used we construct a Karnaugh map (fig. A.1). The projectors are denoted A, B, C, D and Q, and we therefore denote the signals which control the projectors a, b, c, d and q. Owing to some mechanical inertia in the projectors these signals arrive about 0.5 - 1 s before the change of slide.

c \ a b / d	00	01	11	10
00	Ø	q	0	q
01	q	Ø	e	Ø
11	0	e	0	e
10	q	Ø	e	Ø

Fig. A.1 Karnaugh map for use of combinations of pulse receiver PR of the four-screen system

a, b, c, d = triggering of the alternative answer projectors
e = scanning with ESAU
q = triggering of the question projector
Ø = irrelevant combination

In order to initiate a test with a series of slides without order of scanning (or triggering of the question projector), one can use the combinations A and B or C and D. This involves the following condition: If A and B or C and D are triggered, nothing more shall take place. This implies 0 in positions 0011 and 1100.

The time for consideration starts with simultaneous display of all alternative answers (A - D). When A, B, C and D are triggered simultaneously, therefore, nothing more must take place. This implies 0 in position 1111.

The question projector Q must be triggered when the correct answer slide disappears from the screen. Only one of alternatives A - D is the correct answer. Therefore Q must be triggered every time one of projectors A, B, C or D is triggered, which implies q in position 0001, 0010, 0100 and 1000.

After ESAU has scanned the student terminals, the distractors must be removed. As ESAU scans immediately on receipt of a scanning pulse and the projectors have the aforesaid delay, the removal of the distractors can be used to trigger the ESAU scan. The projectors are unable to react until the scan has been completed. As there are always three distractors, ESAU must be triggered for scanning every time three projectors are triggered simultaneously. This implies e in positions 0111, 1011, 1101 and 1110.

The distractor removal signal has another function, namely to transmit the correct answer to ESAU, the correct answer being generated by the absence of a signal to the projector which is not triggered. The Karnaugh map in fig. A.1 shows that all necessary operations can be accommodated in the earlier four-screen system provided that suitable combinations are used.

Modification of pulse receiver

The pulse receiver PR from the earlier four-screen system has been equipped with outputs which deliver complementary signal values for the alternative projectors, i.e. a, b, c and d. The pulse receiver has also been given an output which delivers a signal g when the entire pulse train has been received by PR.

Correct answer and question decoder

The CAQ decoder contains a monostable flip-flop which is triggered by g, thereupon delivering a pulse h with pulse time 1.7 ms. It is during this time that ESAU scanning and triggering of the question projector take place.

Scanning takes place on the condition $h \cdot e$ and triggering of the question projector on the condition $h \cdot q$. (See also fig. A.6.)

The correct answer signal to ESAU, on the other hand, need not be multiplied by h, as it makes no difference which signal is available during the period between scannings.

The connections to ESAU must be adapted to DTL, i.e. "0" must be a short-circuit to earth. Signals $\overline{a}$, $\overline{b}$, $\overline{c}$ and $\overline{d}$ do not fulfil this condition. The outputs to ESAU must then consists either of a transistor or of a DTL circuit. An inverter will in such case always be used as final stage.

Variable synthesis

Correct answer	x	y	z	
A	1	0	0	$\bar{a}bcd$
B	0	1	1	$a\bar{b}cd$
C	0	1	0	$ab\bar{c}d$
D	0	0	1	$abc\bar{d}$

Fig. A.2 Truth table for setting of ESAU to the correct answer when x, y and z are the correct answer variables required by ESAU.

The truth table for setting of ESAU to the correct answer is shown in fig. A.2. As the correct answer, as pointed out earlier, is represented by the projector which is not activated, the Karnaugh maps for x, y and z will be as shown in fig. A.3. The groups are arranged out of consideration for the fact that only inverted variables are available. As, for the aforementioned reason, the circuit must have an inverter on the output, signals $\bar{x}$, $\bar{y}$ and $\bar{z}$ will be available.

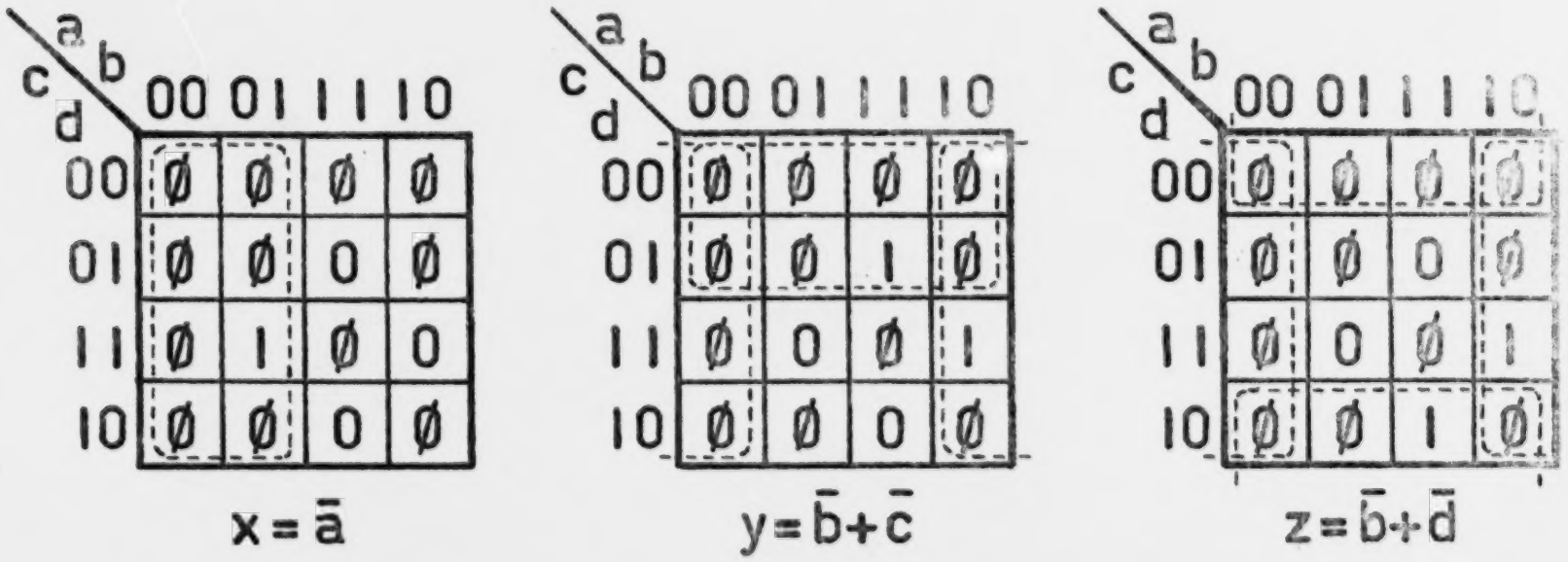


Fig. A.3 Karnaugh map for calcultation of the correct answer variables x, y and z

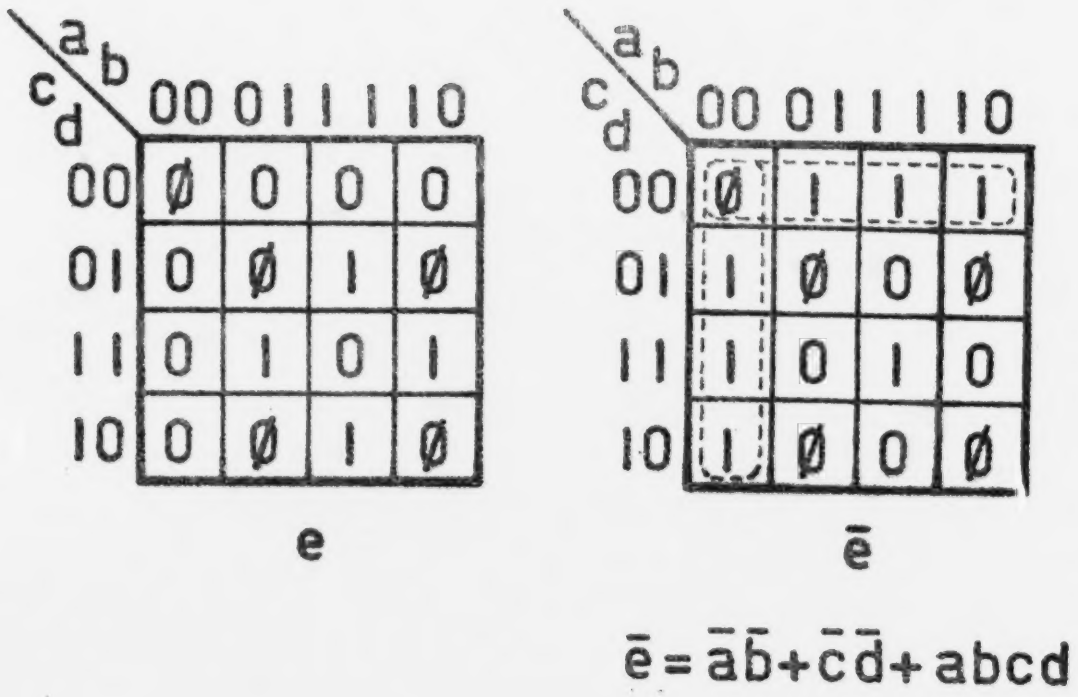


Fig. A.4 Karnaugh map for calculation of the scanning variable e

The scan is triggered by $e \cdot h$. This output as well is inverted, and it is then appropriate that it should be a NOR circuit, as $e \cdot h = \overline{(\bar{e} \cdot \bar{h})} = \overline{(\bar{e} + \bar{h})}$. The diagram for e, which is an inverted e diagram, is shown in fig. A.4. This all looks quite nice if one disregards the term $a \cdot b \cdot c \cdot d$, which, on account of the inverted variables, must be expressed as $a \cdot b \cdot c \cdot d = \overline{(\bar{a} + \bar{b} + \bar{c} + \bar{d})}$. This implies a NOR circuit. But $\bar{x}$, $\bar{y}$ and $\bar{z}$ are available. $\bar{x} = \bar{\bar{a}} = a$, $\bar{y} = \overline{\bar{b} + \bar{c}} = b \cdot c$, $\bar{z} = \overline{\bar{b} + \bar{d}} = b \cdot d$ and $\bar{x} \cdot \bar{y} \cdot \bar{z} = a(b \cdot c)(b \cdot d) = a \cdot b \cdot c \cdot d$. We can thus manage with an AND circuit and $\bar{e} = \bar{a} \cdot \bar{b} + \bar{c} \cdot \bar{d} + \bar{x} \cdot \bar{y} \cdot \bar{z}$.

Finally the diagram of q is shown in fig. A.5. The condition for the question projector is then: $h \cdot q = h(\bar{a} \cdot \bar{c} + \bar{b} \cdot \bar{d}) = h \cdot \bar{a} \cdot \bar{c} + h \cdot \bar{b} \cdot \bar{d}$. A logic circuit for PR and CAQ is shown in fig. A.6. The detailed circuits are shown in Appendix B.

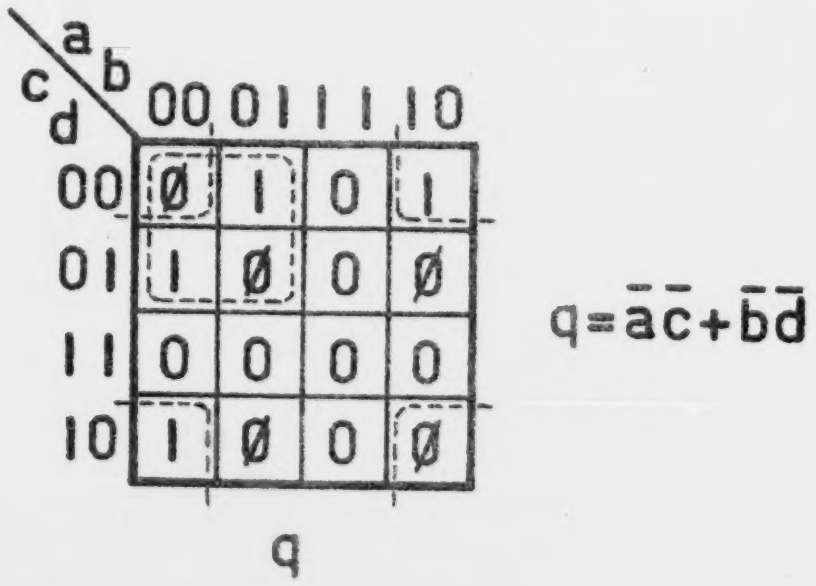
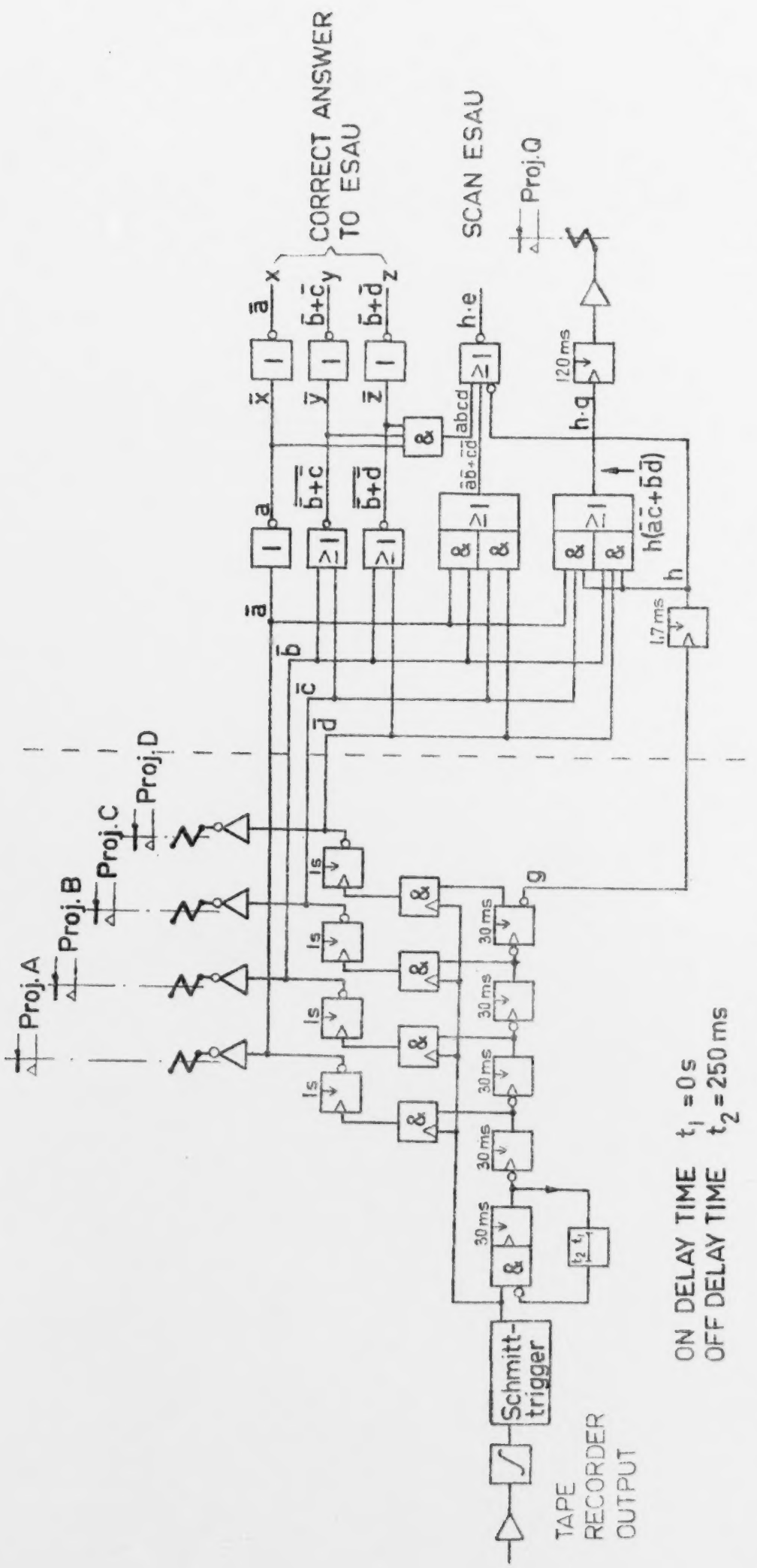


Fig. A.5 Karnaugh map for calculation of the question variable q



Correct answer and question decoder
CAQ

Fig. A.6 Logic circuit for pulse receiver (PR) and correct answer and question decoder (CAQ)

Programming unit for recording

To generate the pulses to be recorded on channel II of the tape, the pulse generator (PG) from the four-screen system is required. One also wants the time for consideration to be indicated both by "ding" about 5 seconds before and by "dong" at the actual moment of scanning. The students then know when they have the last chance to press their answer button.

As the question-and-answer cycles are fairly similar, it is advisable to let a programming unit (PU) control both PG and an acoustic signal unit ("ding-dong"). A sketch of the recording equipment is shown in fig. 7. The specification for PU is shown in fig. 6 in the form of a panel and some of the functions. The way in which these functions should be used will be seen from fig. 5.

A programming unit is fairly easily produced with a series of monostable flip-flops which trigger one another in succession. The outputs from the monostable flip-flops then trigger the respective function units.

The logic circuitry for PU and PG is shown in fig. A.7. Attention has been paid to the fact that PG to a large extent already existed (pulse generator for four-screen system) and that PU would therefore be a separate box which must be easily disconnectable. In other words, the cable between the boxes must have as few conductors as possible without thereby unnecessarily complicating the design. The detailed circuits for PU, PG and acoustic signal unit are shown in Appendix B.

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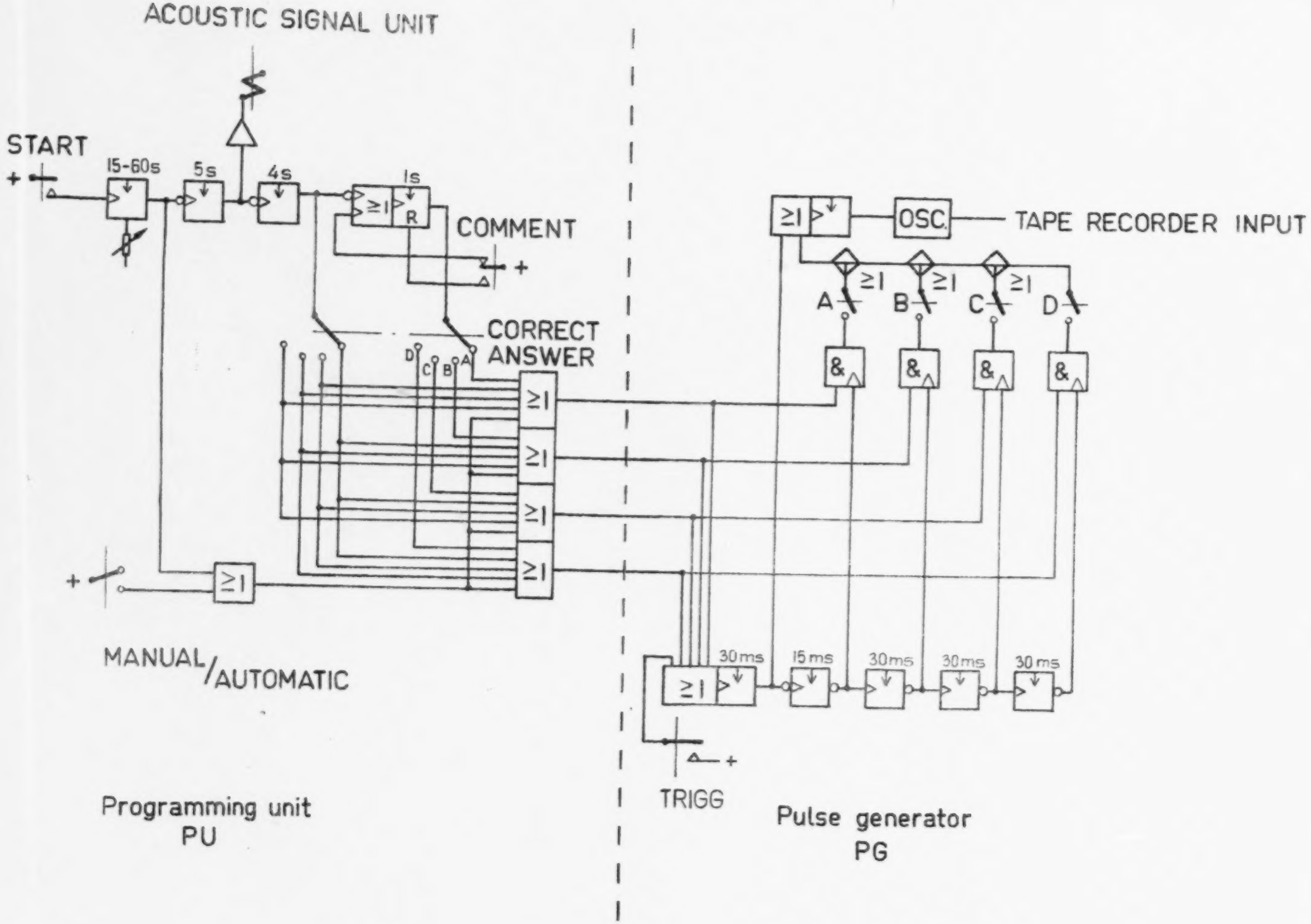

Fig. A.7 Logic circuitry for programming unit (PU) and pulse generator (PG)

APPENDIX B. DETAILED CIRCUITS

B.1 PR, pulse receiver

B.2 CAQ, correct answer and question decoder

B.3 PG, pulse generator

B.4 PU, programming unit

B.5 Acoustic signal unit

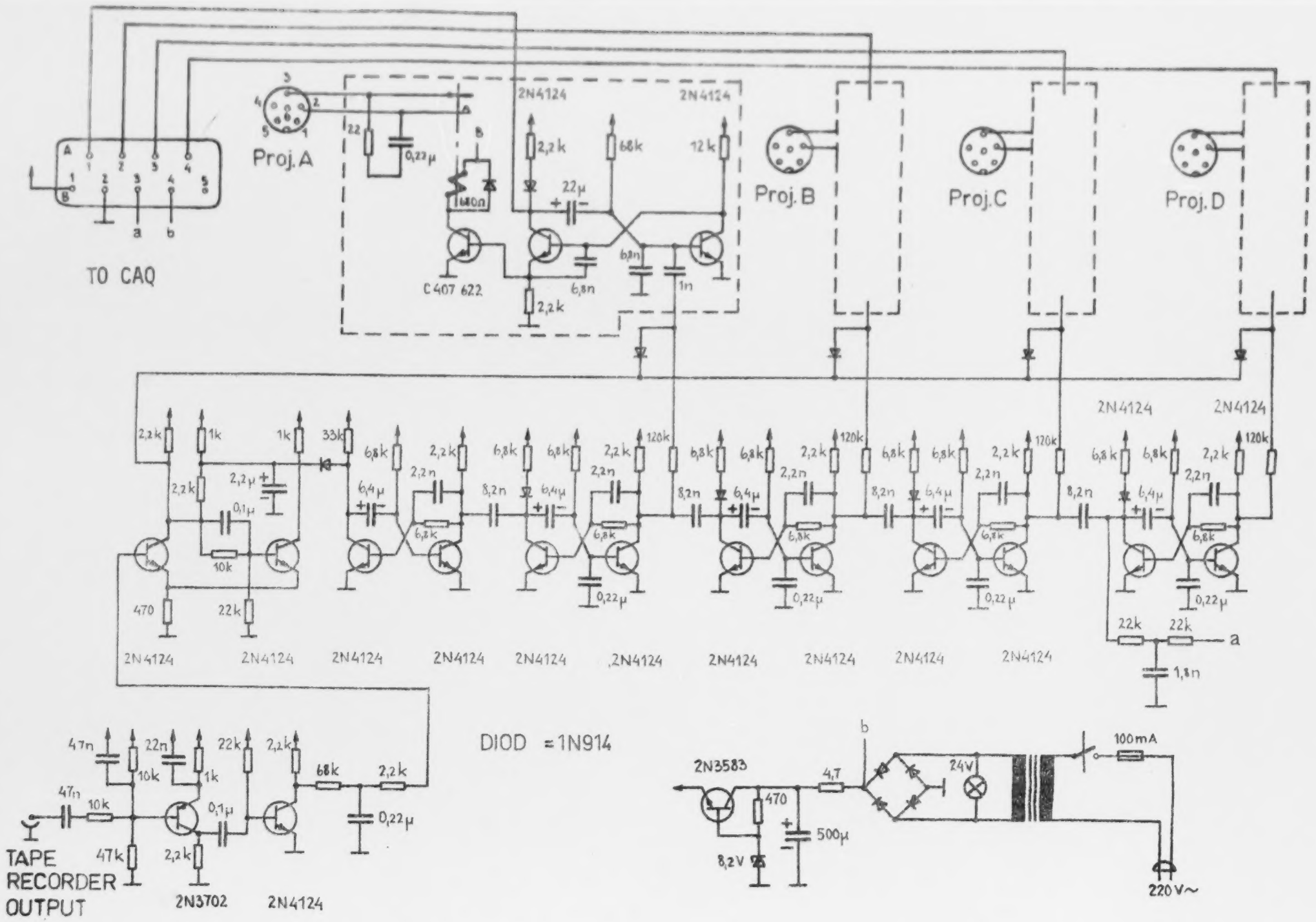

Fig. B.1 PR, the pulse receiver, receives pulses from channel II of the tape recorder, controls the projectors A, B, C and D, and sends the necessary signals to CAQ

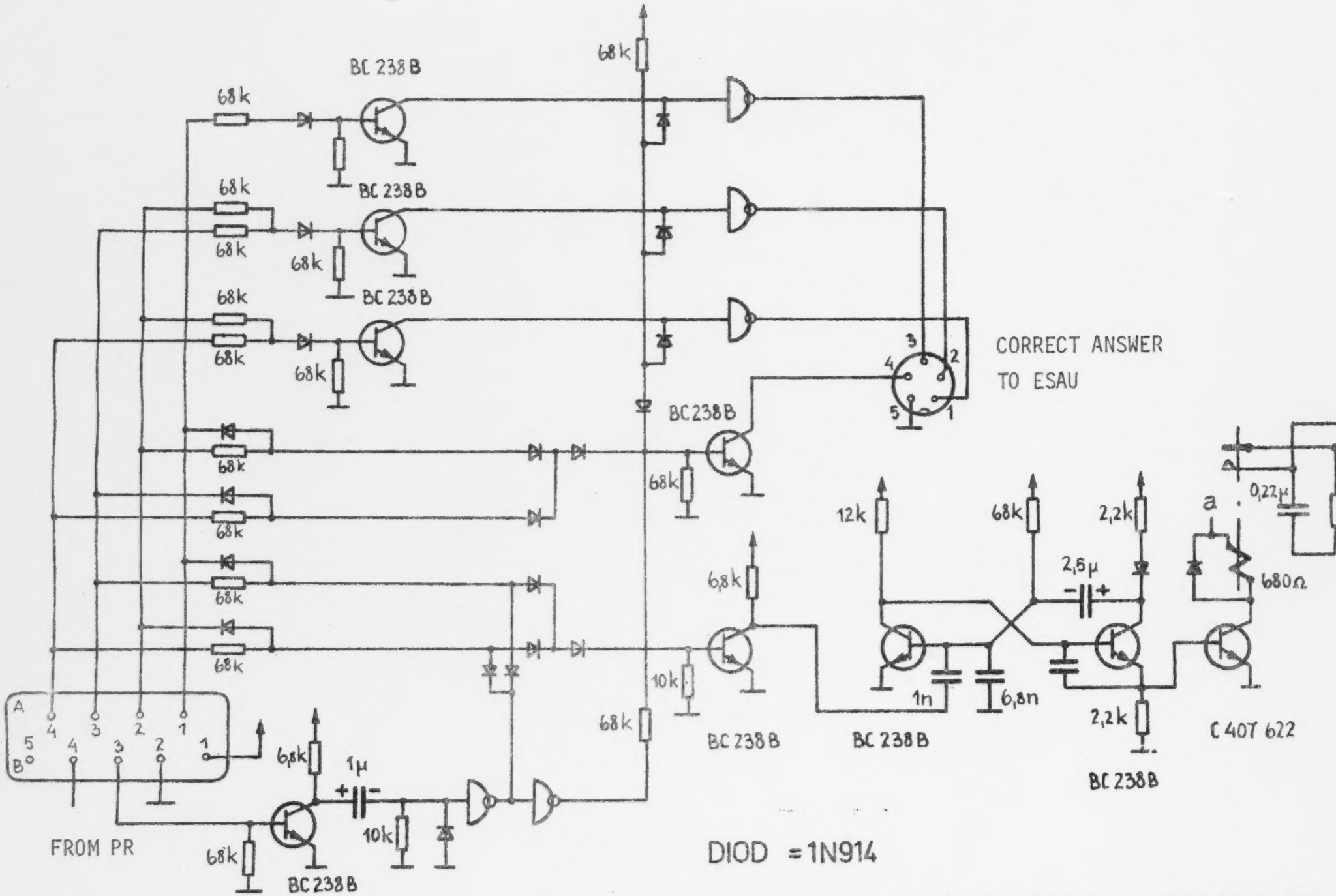

Fig. B.2 CAQ, the correct answer and question decoder, transmits the correct answer to ESAU and triggers the question projector

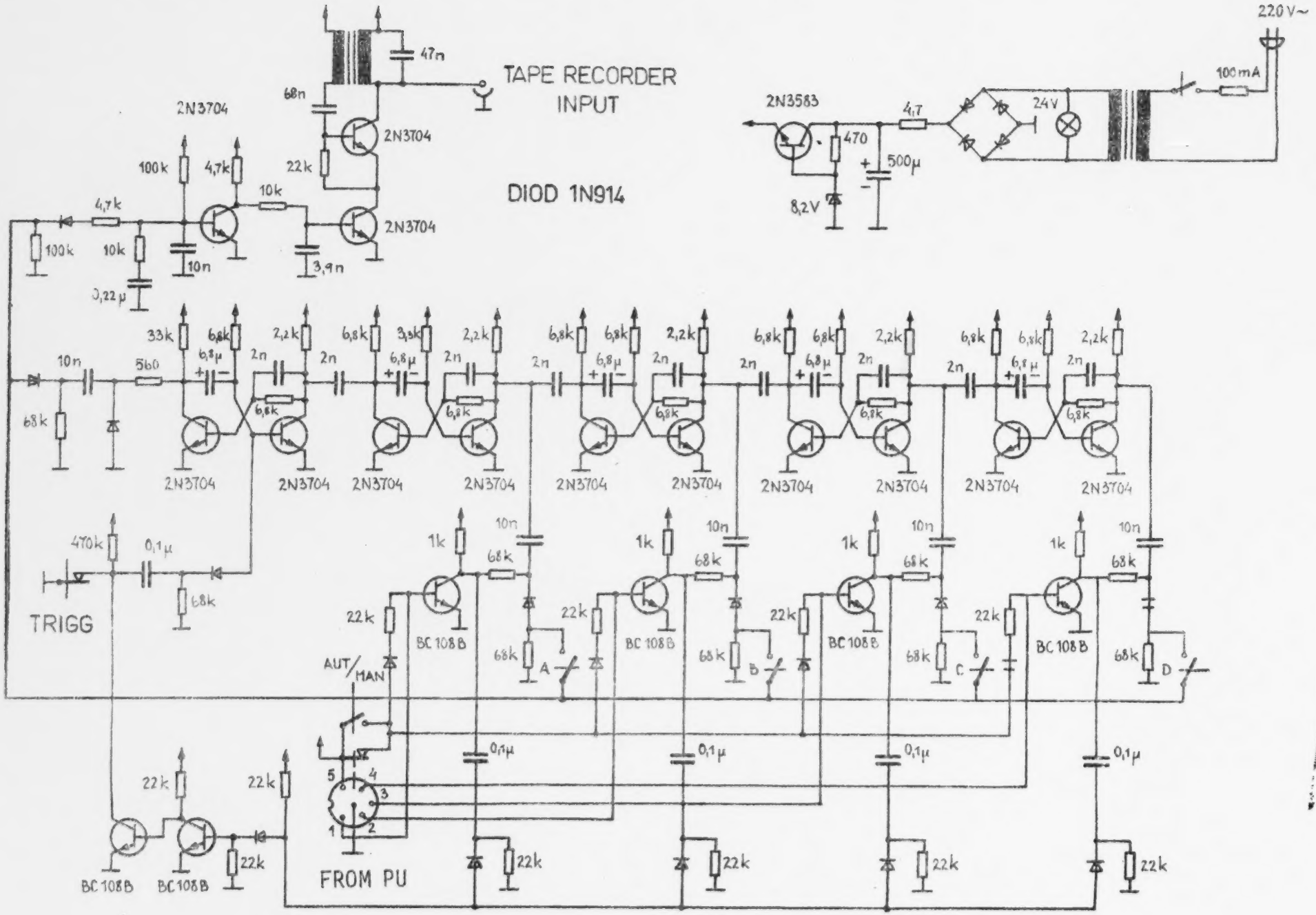

Fig. B.3 PG, the pulse generator, generates and records pulses on channel II of the tape recorder

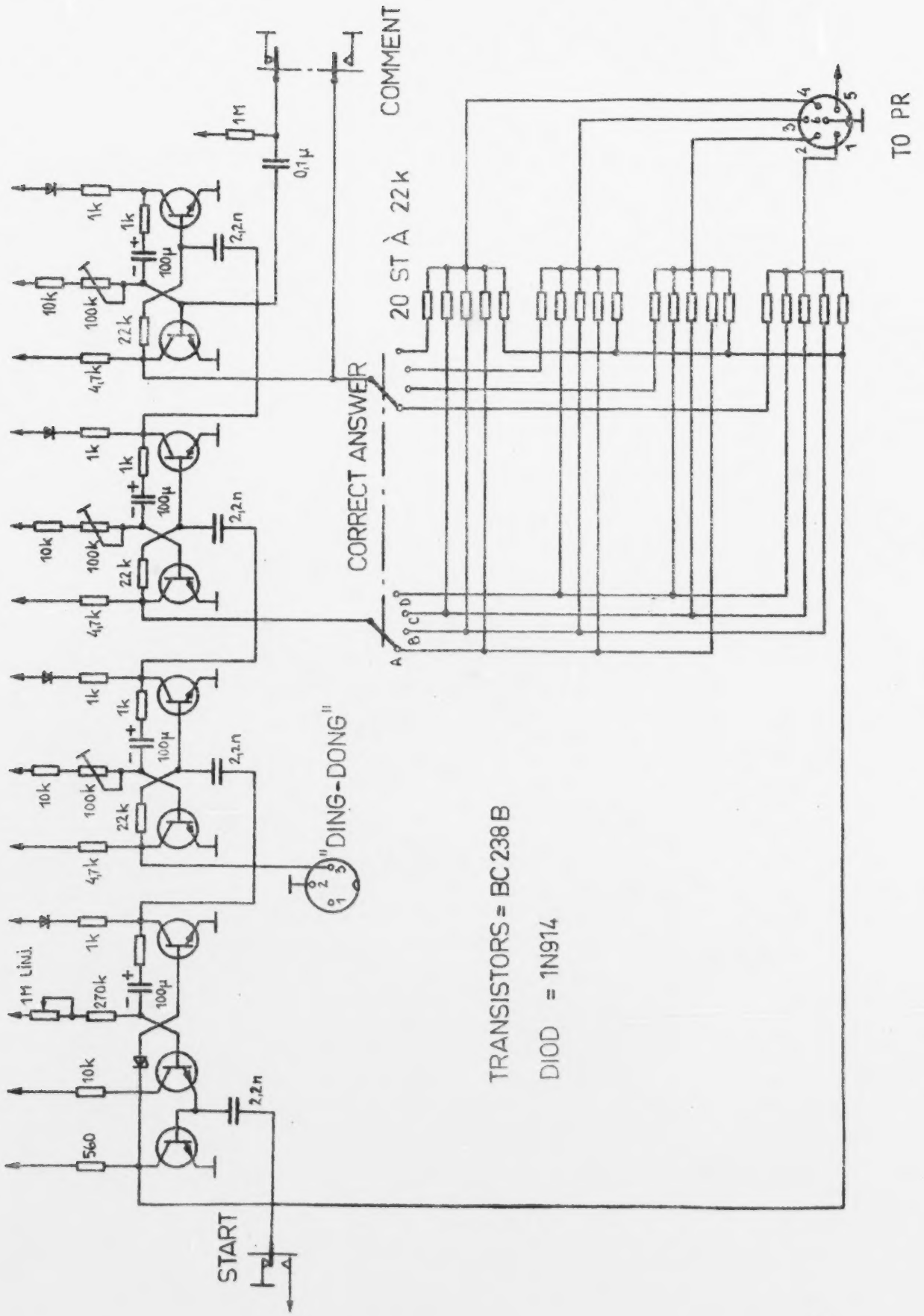

Fig. B.4 PU, the programming unit, controls PG and the acoustic signal unit

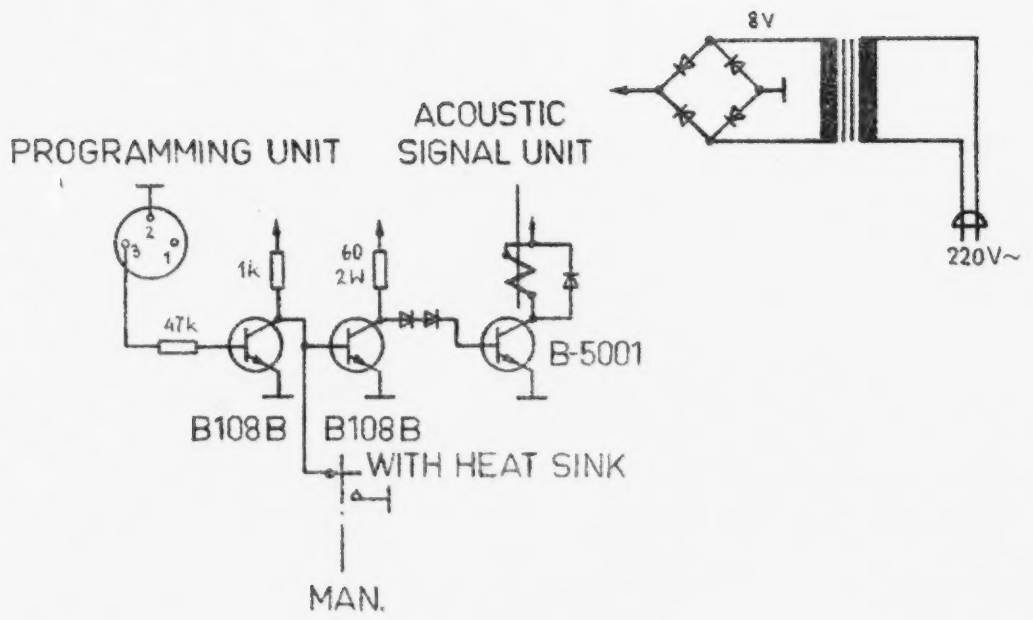

Fig. B.5 Acoustic signal unit